CLAIMS

What is claimed is:

1. An apparatus for determining the diffusion length of semiconductor wafers comprising:

a probe for directing radiation on an area of back side wafer surface to excite charge carriers, create and detect a surface photovoltage, said probe including an electrode, a transparent element placed on surface of the transparent element in the path of said radiation, and a non transparent element surrounding a said transparent element, said electrode is placed in proximity to the back side of the wafer,

means for illuminating of the surface at different wavelengths, including two or more different sources of monochromatic light driven by light drivers controlled by computer,

means for directing light flux onto said electrode of the probe and photo detector,

means for measuring surface photovoltage (SPV) signals picked up by said electrode, said measuring system including SPV pre-amplifier and lock-in amplifier with said electrode connected to said pre-amplifier input, said pre-amplifier output connected to said lock-in amplifier input and said lock-amplifier output connected to computer,

means for measuring light flux including pre-amplifier with said photo detector connected to pre-amplifier input and said pre-amplifier output connected to computer,

an optical system installed from the front surface of the wafer coaxially with said electrode, said optical system being designed for pattern recognition, said optical system including objective lens and CCD matrix with said CCD matrix output connected to computer,

means for positioning said optical system coaxially with said probe electrode, and

means for wafer positioning using for measurements in different locations including one or more linear stages and a rotary stage, said stages controlled by computer.

2. An apparatus as in Claim 1, wherein the transparent element of the probe electrode is the transparent glass or quartz disk, said transparent disk has a transparent and conducting coating on its top and side surfaces, said transparent being disk installed inside the metal ring with a diaphragm covering a part of said transparent disk excluding the central region.

3. An apparatus as in Claim 2, wherein the diameter of said central region is in the range 0.1-1 mm and the outer diameter of the metal ring is 8-10 mm.

4. An apparatus as in any one of Claims 1-3, wherein means for illuminating the wafer surface includes laser diodes installed in the optical combiners, said optical combiners coupled with optical fibers.

5. An apparatus as in any one of Claims 1- 4, wherein the means for directing light flux onto a transparent substrate of the probe includes a Y-shaped optical fiber, with one end of the optical fiber connected to the optical collimator installed in proximity with said transparent element, and the other end of the optical fiber splits light flux between said transparent element and the photo detector.

6. An apparatus as in any one of Claims 1-5, wherein said apparatus further comprises:

a second probe for directing radiation on an area on the back side wafer surface to excite charge carriers, create and detect a surface photovoltage from back side of the wafer, said probe including an electrode including transparent element and a non-transparent element, where said transparent element placed on the path of said radiation and said non-transparent element surrounding said transparent element, said electrode is placed in proximity to the back side of the wafer,

a second means for illumination of the back side of the wafer surface at different wavelengths, including different sources of monochromatic light driven by light drivers controlled by computer,

a second means for directing light flux onto said transparent element of said electrode of the probe and photo detector,

a second means for measuring surface photovoltage signals picked up by said electrode including a pre-amplifier and a lock-in amplifier with said electrode connected to said pre-amplifier input, said pre-

amplifier output connected to said lock-in amplifier input and said lock-amplifier output connected to a computer, and

a second means for measuring light flux including pre-amplifier with said photo detector connected to pre-amplifier input and said pre-amplifier output connected to computer.

7. An apparatus as in Claim 6, wherein the transparent element of the probe is a transparent glass or quartz disk, said transparent disk having a transparent and conducting coating on its top and side surfaces, said transparent disk installed inside a metal ring.

8. An apparatus as in Claim 7, wherein the diameter of said transparent disk is in the range 1-7 mm and outer diameter of the metal ring is 8-14 mm.

9. An apparatus as in any one of Claims 6-8, wherein said second means for illuminating a wafer surface includes light emitting diodes (LED) with interference optical filters, said LED's coupled with optical fiber bundles.

10. An apparatus as in any one of Claims 6-9, wherein the second means for directing light flux onto a second transparent element of the probe includes Y-shaped optical fiber bundles, where one of the end of these optical fiber bundles is coupled with said SPV probe and the other end of the optical fiber bundles splits light flux between said second transparent element of said probe electrode and said photo detector.

11. An apparatus as in any one in Claims 6-10 wherein said apparatus includes two or more SPV units used for said apparatus throughput improvement.

12. A method for determining diffusion length in predetermined regions of the wafer, comprising:

positioning the wafer, using a pattern recognition system to get the predetermined region of the wafer over the illumination area on back side wafer surface,

illuminating said area on back side wafer surface with frequency modulated light with predetermined intensities at a series of wavelengths, λ_i, measuring light fluxes Φ_i directed onto said illumination area and measuring photovoltages V_i from said illuminating area,

illuminating said area at different intensities at the same wavelength λ_1, measuring light fluxes Φ_1 and Φ_{11} and corresponding surface photovoltages V_1,

recalculating SPV signals using the formulas:

$$C_{NL} = \frac{V_{11} \cdot \Phi_1^2 - V_1 \cdot \Phi_{11} \cdot \Phi_1}{V_{11} \cdot \Phi_1^2 - V_1 \cdot \Phi_{11}^2}$$

$$V_i^L = \frac{1 - C_{NL}}{1 - C_{NL} \cdot V_i / V_1} V_i \quad \text{, and}$$

determining the diffusion length using values Vi^l, Φ_i and intercept of the plot Φ_i / Vi^l versus light penetration depth.

13. A method as in Claim 12 wherein the wafer is positioned using a pattern recognition system to get the predetermined region of the wafer within the scribe line over the illumination area on the back side wafer surface.

14. A method as in Claim 12, wherein the light wavelengths are in the range 800-1000 nm.
15. A method as in Claim 12, wherein the light modulating frequency is in the range 400-5000Hz.
16. A method as in Claim 12, wherein multiple SPV probes are used simultaneously.
17. A method as in Claim 12, wherein one or several pulses of light at one wavelength alternate with one or several pulses of light at different wavelength.